Journal of Plastic, Reconstructive & Aesthetic Surgery (2017) 70, 229–235

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Vertical breast measurement in East Asian women: A guide for mastopexy and reduction to form nonptotic breasts in unilateral prosthetic breast reconstruction

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Received 14 July 2016; accepted 3 October 2016

KEYWORDS
Mastopexy;
Reduction;
Nonptotic breast;
Unilateral prosthetic breast reconstruction;
Vertical breast measurement;
Implant

Summary *Background:* Following unilateral breast cancer surgery, mastopexy and reduction of the unaffected breast are often performed to obtain symmetrical breasts. The use of implants in breast reconstruction results in a nonptotic breast. To achieve symmetry following the procedure, the unaffected side should be nonptotic too. However, no study has yet reported any indices for the design of mastopexy and reduction in this direction. We present a new method of preoperative design that uses vertical breast measurements to form nonptotic breasts according to individual breast shapes.
Methods: We performed vertical breast measurements of the unaffected breasts of 193 patients scheduled to undergo surgery for unilateral breast cancer. The vertical base dimension (VBD) and vertical surface dimension (VSD) of the ptotic and nonptotic breasts and the height of the nipple in the nonptotic breast were measured in centimeters.
Results: The borderline between ptotic and nonptotic breasts was expressed using the formula VSD = 1.13 × VBD + 1.86. The height of the nipple in nonptotic breasts was 0.8 times the distance between the sternal notch and lowest point of the inframammary fold on the midline. From these findings, we formulated a new method for forming a nonptotic breast from a ptotic breast using an inverted T design.
Conclusion: These results can be used for the design of mastopexy and reduction when forming a nonptotic breast on the unaffected side. These procedures can be performed without

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http://dx.doi.org/10.1016/j.bjps.2016.10.003

significantly lifting the nipple—areolar complex if required during unilateral prosthetic breast reconstruction.

Introduction

During breast reconstruction after unilateral breast cancer surgery, mastopexy and reduction of the unaffected breast are often performed to obtain symmetrical breasts. Ptotic breasts can be formed by breast reconstruction with autologous tissue. Moreover, a ptotic postoperative breast shape following mastopexy and reduction of the unaffected side is unproblematic as long as there is no difference between the left and right breasts. However, in cases of implant reconstruction, the unaffected side should preferably be nonptotic because the use of an implant results in a nonptotic reconstructed breast.[1] Preoperative marking is important for this type of surgery, and determining the length of the skin of the breast in the longitudinal orientation in particular is essential.[2] Previous studies have described the measurements of normal breasts[3–6] and those regarded as exceptionally cosmetically pleasing.[7,8] Furthermore, most surgeons base their preoperative marking on these data and on their own experience. Thus, they perform preoperative marking with reference to the mean or the recommended values of a range of parameters, particularly the distance from the sternal notch (SN) to the nipple and from the nipple to the inframammary fold (IMF). However, given the variety in the longitudinal diameter and volume of the breasts of individual patients, in many cases, these mean values or the recommended ones are not actually applicable in practice. No study has yet reported indices for design to form a nonptotic breast on the unaffected side when this is required because of unilateral breast reconstruction with an implant. Thus, a new method of preoperative design that can be adapted for use in individual patients is required. We considered that the length of the skin of the breast in the longitudinal orientation is an important factor when determining the shape of the breast. Therefore, we have introduced a procedure that uses vertical breast measurements to implement preoperative designs in accordance with the shape of the individual breast. We describe here the detailed measurements and the design of mastopexy or reduction to form a nonptotic breast on the unaffected side when implants are used for breast reconstruction.

Patients and methods

We obtained measurements of the unaffected breast during the preoperative examinations of the patients that were scheduled to undergo surgery for unilateral breast cancer at our hospital. These measurements were performed on 193 patients between January 2014 and December 2015. The measured parameters were the vertical base dimension (VBD), which was defined as the distance between the SN and the intersection of the IMF and a straight line drawn caudad from the nipple, and the vertical surface dimension (VSD), which was defined as the distance between the SN and IMF. VBD was measured using calipers and VSD was measured using a tape that was passed over the nipple. Ptotic breasts were lifted up by hand while the measurements were obtained (Figure 1). For nonptotic breasts, we measured the distance between the SN and position of the nipple on the midline (NM) and the distance between the SN and the position of the IMF on the midline (IMFM). Furthermore, the ratio of these two distances (SN—NM/SN—IMFM) was calculated (Figure 2). Breasts were defined as nonptotic if there was no contact between the skin of the breast and the skin of the chest wall in the standing position and as ptotic if there was contact. The statistical software used was BellCurve for Excel (Social Survey Research Information Co., Ltd., Tokyo, Japan).

Results

Of the 193 patients, 153 had nonptotic breasts, whereas 40 had ptotic breasts. Patient demographics are shown in Table 1.

The relationship between ptosis and VSD

For the 153 patients with nonptotic breasts, VBD ranged between 19.2 and 25.1 cm, with a mean value of 22.4 cm, whereas VSD ranged between 20.5 and 29.8 cm, with a mean value of 24.2 cm. For the 40 patients with ptotic breasts, VBD ranged from 19.7 to 25.9 cm, with a mean value of 23.1 cm, whereas VSD ranged from 26.0 to 39.5 cm, with a mean value of 31.3 cm. The distributions are shown in Figure 3. For the same VBD value, the VSD of the ptotic breasts was longer than that of the nonptotic breasts. The discriminant function of the threshold value between ptotic and nonptotic breasts as calculated by the discriminant analysis was $VSD = (1.13 \times VBD) + 1.86$.

Nipple position in nonptotic breasts

The SN—NM/SN—IMFM ratio in the 153 patients with nonptotic breasts ranged from 0.68 to 0.89, with a mean value of 0.78. The distribution is shown in Figure 4. In nonptotic breasts, the nipple was positioned averagely so that the SN—NM/SN—IMFM ratio was approximately 0.8.

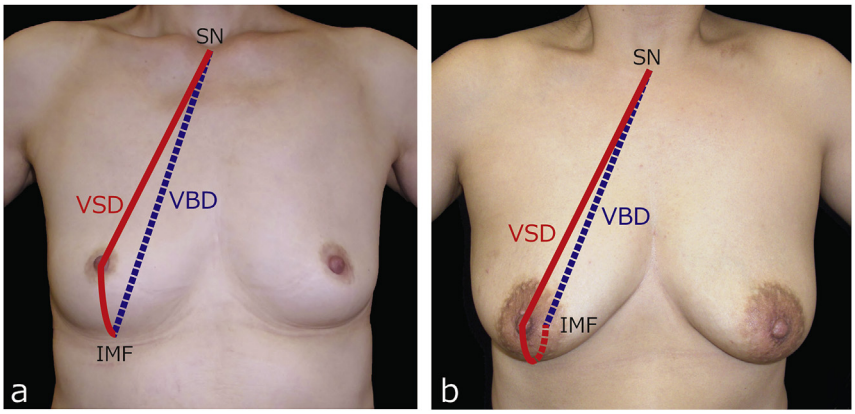

Figure 1 Measurement of VBD and VSD in nonptotic breasts (a) and ptotic breasts (b). Ptotic breasts were lifted up by hand while the measurements were obtained. VBD, vertical base dimension; VSD, vertical surface dimension.

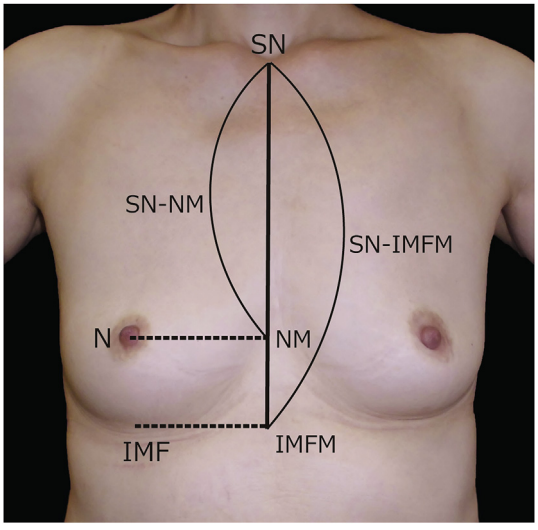

Figure 2 Measurement of the nipple position in a nonptotic breast. SN, sternal notch; N, nipple; IMF, the point of intersection of the inframammary fold and a straight line drawn caudad from the nipple; NM, the position of the nipple on the midline; IMFM, the position of the IMF on the midline.

Application in prosthetic breast reconstruction

In our hospital, an expander is inserted following total mastectomy. Moreover, depending on whether mastopexy or reduction of the unaffected breast is required, the procedure is performed at the same time as the expander is exchanged for an implant. While the expander is being enlarged by means of saline injections, the patient is asked to check the feel of the expander by palpating it. In addition, she is asked to confirm the desired final volume of the breast. This information is used as a guide to determine the size of the inserted implant and whether reduction of the unaffected side is required.

The preoperative design

The inverted T design (Figure 5) that we frequently use may be described as follows. Ptotic breasts have more VSD than nonptotic breasts; thus, decreasing the VSD to threshold value, namely to the value corresponding to nonptotic breasts, will eliminate ptosis (Figure 3). Therefore, we measured the patient's VBD and calculate the desired VSD according to the discriminant function for the threshold

Table 1 Mean values ± SD for nonptotic and ptotic breast.

	Nonptotic breast (n = 153)	Ptotic breast (n = 40)
Age, years (range)	47.3 ± 8.3 (26–68)	52.5 ± 8.9 (35–71)
Height, cm (range)	159.5 ± 5.0 (142.0–174.6)	157.9 ± 5.5 (138.0–168.0)
Weight, kg (range)	52.5 ± 6.5 (38.0–76.0)	58.7 ± 9.0 (43.0–76.6)
BMI, kg/m^2 (range)	20.6 ± 2.4 (14.6–29.3)	23.5 ± 3.2 (18.8–32.0)
VBD, cm (range)	22.4 ± 1.3 (19.2–25.1)	23.1 ± 1.5 (19.7–25.9)
SN–N, cm (range)	18.8 ± 1.4 (14.7–22.0)	22.8 ± 2.2 (18.5–28.5)
N–IMF, cm (range)	5.3 ± 0.9 (3.6–8.6)	8.5 ± 1.4 (5.2–11.5)
VSD, cm (range)	24.2 ± 1.8 (20.5–29.8)	31.3 ± 2.9 (26.0–39.5)
Areolar diameter, cm (range)	3.0 ± 0.6 (1.9–5.1)	4.2 ± 1.0 (2.8–6.8)

SD, standard deviation; BMI, body mass index; VBD, vertical base dimension; SN–N, distance between the sternal notch and the nipple; N–IMF, the distance between the nipple and the point of intersection of the inframammary fold and a straight line drawn caudad from the nipple; VSD, vertical surface dimension.

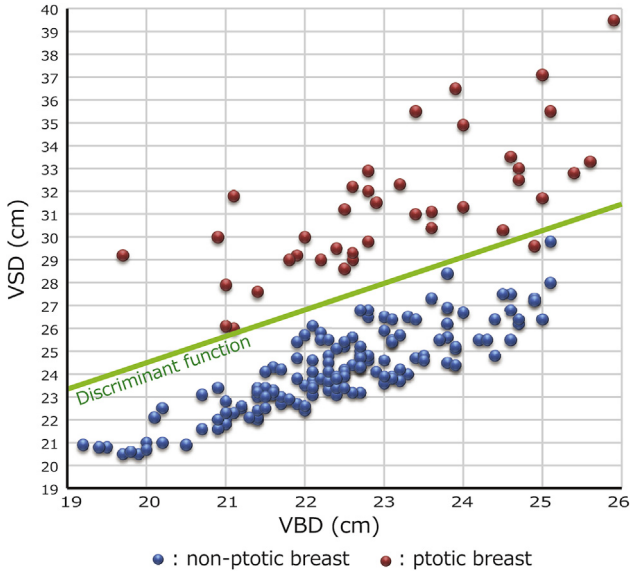

Figure 3 Measured values of VBD and VSD. The value of VSD corresponding to the threshold value that marks the difference between ptotic and nonptotic breasts can be calculated by discriminant analysis as VSD = (1.13 × VBD) + 1.86 (all measurements in centimeters). VBD, vertical base dimension; VSD, vertical surface dimension.

value between ptotic and nonptotic breasts: VSD = (1.13 × VBD) + 1.86. The new nipple position (N′) is located on the breast meridian. If nipple-sparing mastectomy is performed, the nipple on the affected breast is preserved. Moreover, a provisional design is produced in which the distance between the SN and N′ (SN—N′) is equal to the distance between the SN and the nipple on the affected side. The length of the vertical limb (VL) is calculated by subtracting SN—N′ from the desired VSD. If skin-sparing mastectomy or total mastectomy is performed, the nipple on the affected breast is not preserved, and its position cannot be used as reference. Thus, N′ is determined by using the mean nipple position for nonptotic breasts. N′ is provisionally assigned to a position on the breast meridian such that the ratio of the distance between the SN and N′ on the midline (SN—N′M) to SN—IMFM is approximately 0.8. VL is the length obtained by subtracting SN—N′ from the desired VSD.

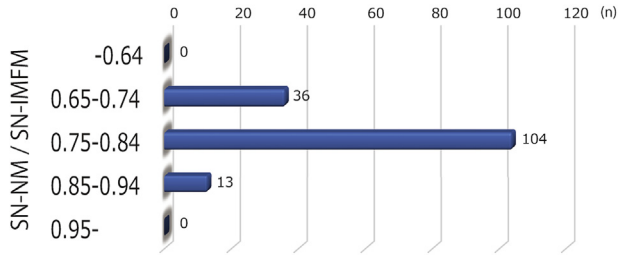

Figure 4 Nipple position in nonptotic breasts. SN, sternal notch; NM, the position of the nipple on the midline; IMF, the point of intersection of the inframammary fold and a straight line drawn caudad from the nipple; IMFM, the position of the IMF on the midline.

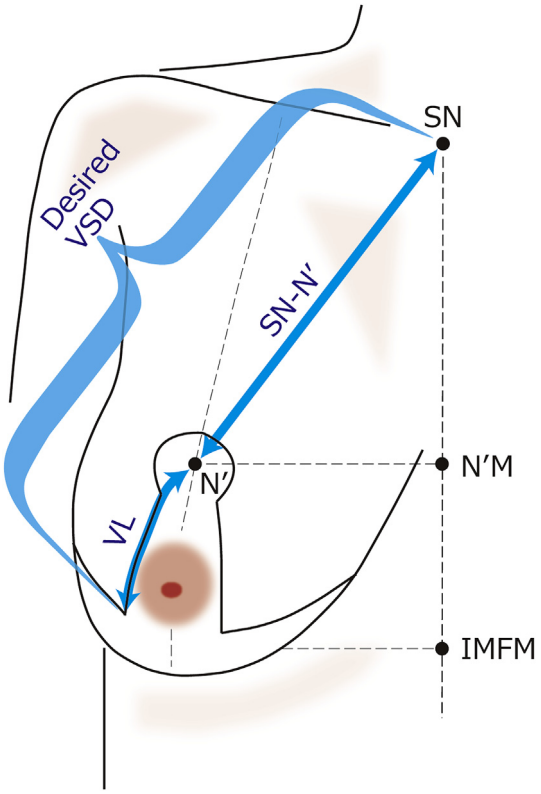

Figure 5 Inverted T preoperative design. Desired VSD = SN—N′ + VL. SN, sternal notch; N′, new nipple position; VL, length of the vertical limb; VSD, vertical surface dimension; N′M, position of N′ on the midline; IMF, the point of intersection of the inframammary fold and a straight line drawn caudad from the nipple; IMFM, the position of the IMF on the midline.

During surgery

During surgery, before the excess skin is removed, we perform a simulation by placing the patient in the seated position, folding the skin, and temporarily fixing the suture line.[9] This is to check whether the length of the desired VSD is correct by confirming whether or not it results in a nonptotic breast. Next, we checked whether the height of N′, which was determined by the design, is satisfactory. If the nipple on the affected side has been preserved, we confirm whether the height of N′ matches the height of the nipple on the affected side with the implant inserted. If the nipple on the affected side has not been preserved, we confirm whether SN—N′M/SN—IMFM ≈ 0.8. If mastopexy or reduction is being performed, the actual position of N′ usually differs from its anticipated position, and any misalignment is corrected at this point. If necessary, a reduction is performed to match the size of the inserted implant in the affected breast.

Design case reports

Figure 6 shows the design procedure used in a case of nipple-sparing mastectomy, and Figure 7 shows the design

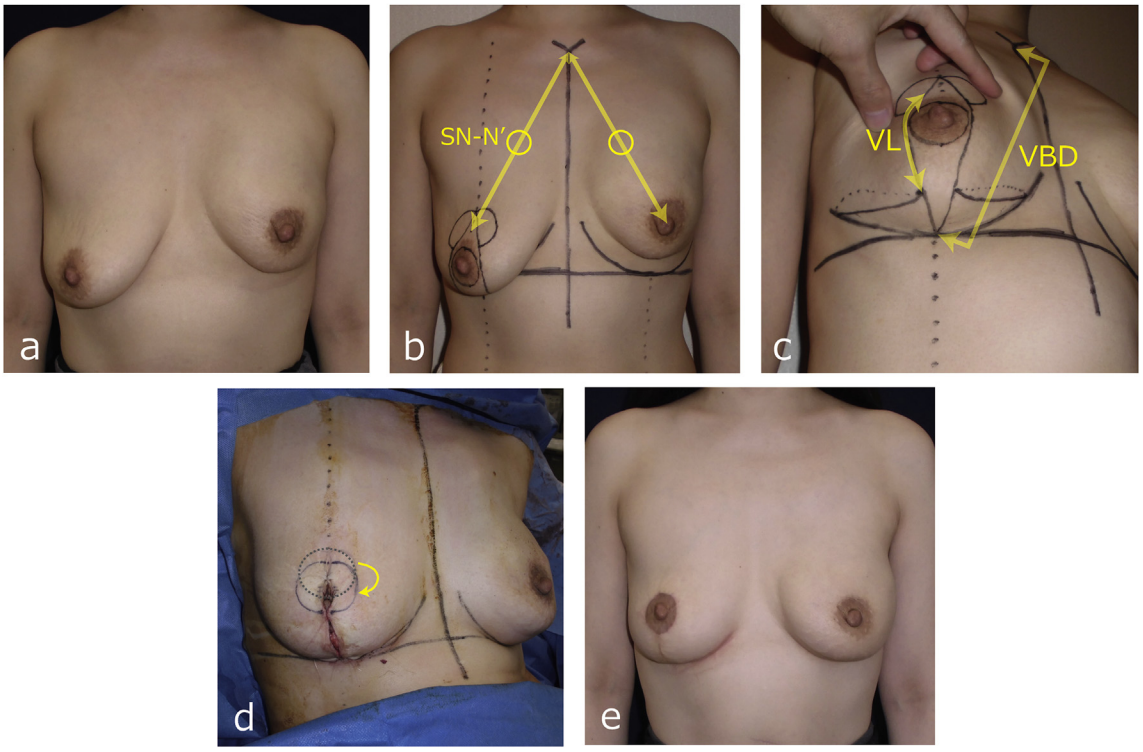

Figure 6 The design for the nipple-sparing mastectomy. a) After the surgery for left breast cancer. An expander (Natrelle® 133 style FV400, Allergan, Dublin, Ireland) was inserted at the same time as a nipple-sparing mastectomy (310 g of tissue removed) was performed. This photograph was taken before the expander was replaced with an implant and inverted T mastopexy was performed on the unaffected side. b) Frontal view of the preoperative design of mastopexy. N′ was designed on the breast meridian so that SN—N′ was 20 cm, which is equal to the distance between SN and the nipple on the affected side. c) Elevation of the preoperative design for mastopexy. VBD on the unaffected side was 23 cm, and the desired VSD was calculated according to the discriminant function as VSD = (1.13 × VBD) + 1.86 = (1.13 × 23) + 1.86 ≈ 28 cm. The VL was provisionally determined as the desired VSD − SN—N′ = 28 − 20 = 8 cm d) Before the skin was removed, a simulation was performed with the patient in the seated position in which the skin was folded and the suture line was temporarily fixed to confirm that the resulting breast shape would be nonptotic. The new position of the nipple—areolar complex (broken line) was slightly craniad to the position of the nipple on the affected breast with the implant (Natrelle® 410 style LL-240, Allergan) inserted; it was corrected from the preoperative design so that the two heights matched (arrow). e) Postoperative photograph. SN, sternal notch; N′, new nipple position; VBD, vertical base dimension; VSD, vertical surface dimension; VL, length of the vertical limb.

procedure used in a case of total mastectomy in which the nipple was not preserved.

Discussion

Breast symmetry is more difficult to achieve in unilateral prosthetic breast reconstruction than in bilateral reconstruction. This is because the use of an implant in breast reconstruction results in a nonptotic reconstructed breast,[1] and mastopexy or reduction of the unaffected breast is frequently necessary to achieve symmetry.[10] When the reconstructed breast, which was formed by breast reconstruction with autologous tissue, is ptotic, it is unproblematic if the postoperative breast shape of the unaffected breast following touch-up surgery is also ptotic. However, when prosthetic breast reconstruction is performed, the unaffected side should also be preferably nonptotic following the procedure.

Among the numerous skin designs that are used to form a nonptotic breast by mastopexy or reduction, the inverted T design is the one that we use most frequently. Ptotic breasts always have excessive skin in both the vertical and horizontal orientations. Furthermore, a well-shaped breast cannot be formed without calculating the extent of excess skin and accurately removing it.[2] The inverted T design has the advantage of enabling the thorough removal of the excess skin. Preoperative design is important, and determining the length of the skin of the breast in the longitudinal orientation is particularly crucial to the formation of a nonptotic breast. Studies have reported the mean values of various parameters based on the measurements of nonptotic breasts[7,8] and breasts of healthy individuals,[3–6] including the distance between the SN and nipple and the distance between the nipple and IMF. However, breast size varies widely among individuals, and in many cases, it is inappropriate to use these mean values for mastopexy and reduction. Preoperative design must therefore be personalized to individual patients. Therefore, we have introduced a method of calculating the VSD comprising the boundary between the ptotic and nonptotic breasts on the basis of vertical breast

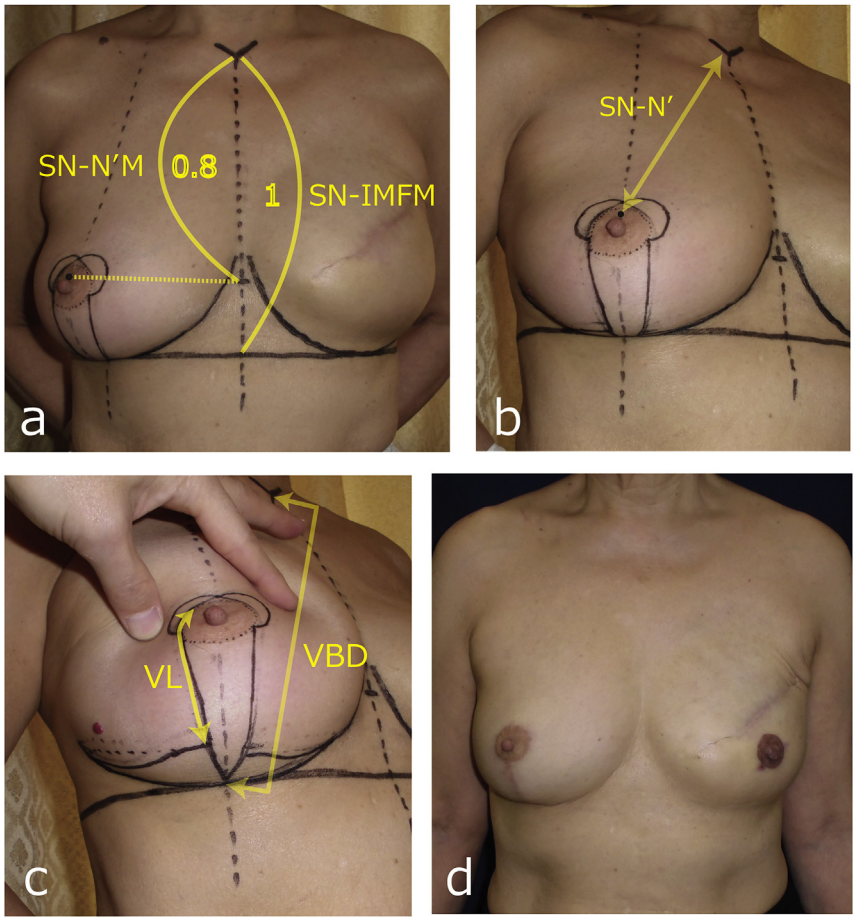

Figure 7 Design for total mastectomy. Following left breast cancer surgery. Total mastectomy was performed. An expander (Natrelle® 133 style MV400, Allergan) was subsequently inserted. Five months later, an inverted T reduction was planned to be performed at the same time as the expander was replaced by an implant. a) Frontal view of the preoperative design of mastopexy. As the nipple on the affected side was not preserved, N′ was marked on the breast meridian at the mean nipple position in nonptotic breasts, such that SN—N′M/SN—IMFM = 0.8. b) SN—N′ was 20.5 cm. c) VBD was 22 cm, and the desired VSD was calculated according to the discriminant function as VSD = (1.13 × VBD) + 1.86 = (1.13 × 22) + 1.86 ≈ 27 cm. The VL was determined as the desired VSD − SN—N′ = 27—20.5 = 6.5 cm. A similar simulation to that implemented in Figure 6 was performed before the resection of the skin. Further, it was confirmed that the resulting breast was nonptotic and that N′ was at the anticipated height. d) An implant (Natrelle® 410 style FL-250, Allergan) was inserted into the affected breast, and a reduction (68 g) of the unaffected breast was performed to match their overall volumes. The photograph shows the postoperative breasts after nipple—areolar complex reconstruction. SN, sternal notch; N′, new nipple position; N′M, position of N′ on the midline; IMF, the point of intersection of the inframammary fold and a straight line drawn caudad from the nipple; IMFM, the position of the IMF on the midline; VBD, vertical base dimension; VSD, vertical surface dimension; VL, length of the vertical limb.

measurements. Preoperative design with reference to this value enables the performance of mastopexy or reduction appropriate for individual patients. No previous study has compared breast measurements for ptotic and nonptotic breasts or calculated the boundary value, and these data will be extremely useful for changing ptotic breasts into nonptotic breasts.

If the nipple—areolar complex of the affected breast has been removed, there is no nipple position to use as a reference when performing mastopexy or reduction of the unaffected breast. If a new nipple position is designed on the basis of the same parameters that have previously been reported, there is a possibility that the nipple will be raised too high. Correction of a too-high nipple—areolar complex, and it may present a strange appearance.[11] Therefore, ensuring that it is not raised too far is important. Thus, we identified a clear marker by calculating the mean position of the nipple in nonptotic breasts. Matching the new nipple position with this marker prevents the nipple from being inadvertently raised too far.

We found that the mean areolar diameter in nonptotic breasts was 3 cm. In principle, the new areolar diameter should reflect the previous areolar diameter; however, if the nipple of the affected breast has been removed and the original areolar diameter is >3 cm, we set the new areolar diameter at 3 cm. When forming a nonptotic breast, it is necessary to match the areolar diameter with the mean value of the nonptotic breasts.

Conclusion

We performed vertical breast measurements on 193 East Asian women and calculated the VSD value that corresponded to the boundary between ptotic and nonptotic breasts. The mean height of the nipple in nonptotic breasts was also obtained. These results will be extremely useful in the design of mastopexy or reduction. One of these techniques may be required in prosthetic breast reconstruction to form a nonptotic breast on the unaffected side without raising the nipple—areolar complex too far.

Conflict of interest statement

None.

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